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(58) Field of Search

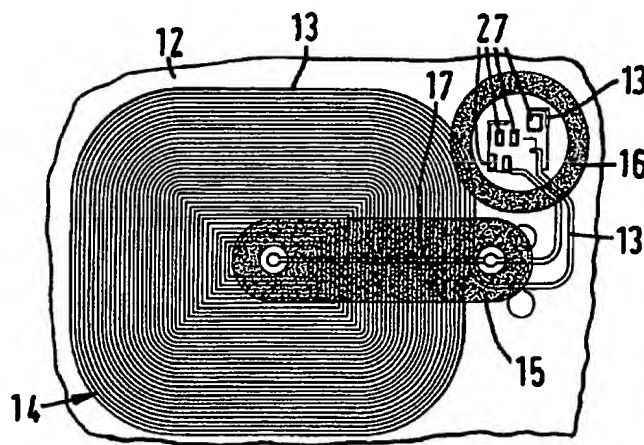
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(54) An integrated circuit or smart card.

(57) A smart card comprises a flexible printed circuit 12 on which components are mounted by means of flexible adhesive 27. The adhesive is the same compound as the encapsulant material and is applied to the printed circuit 12 by screen printing to areas where there are no conductive tracks 13. The electrical connections are made by wire bonding.

FIG. 6



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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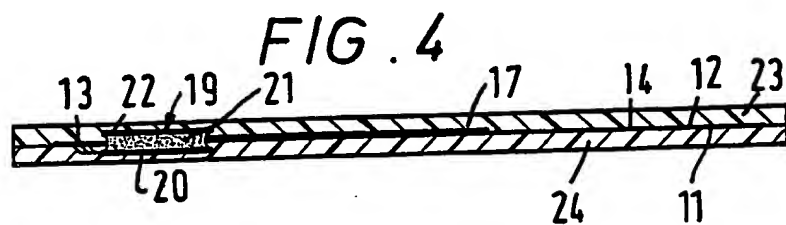
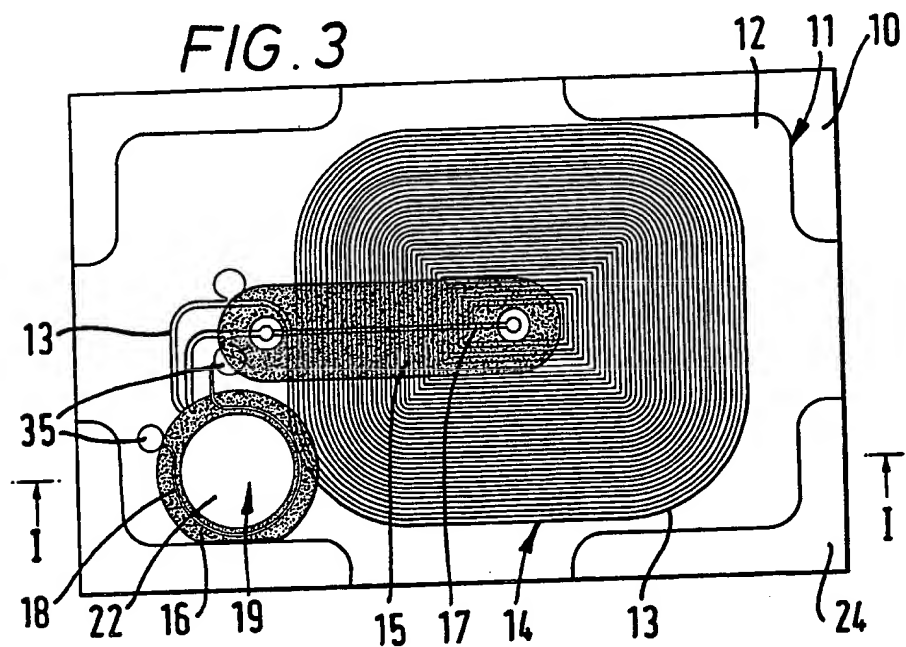
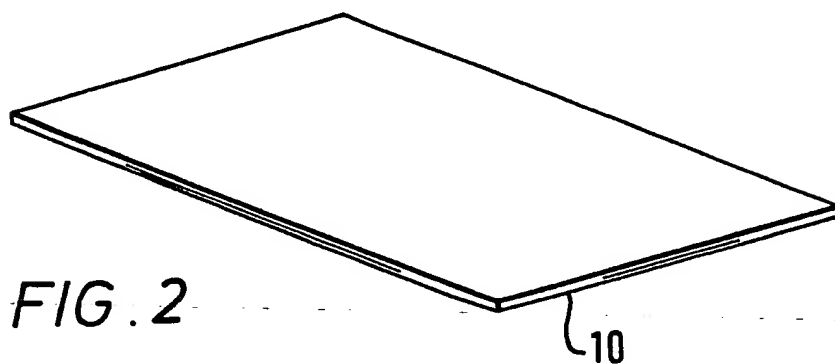
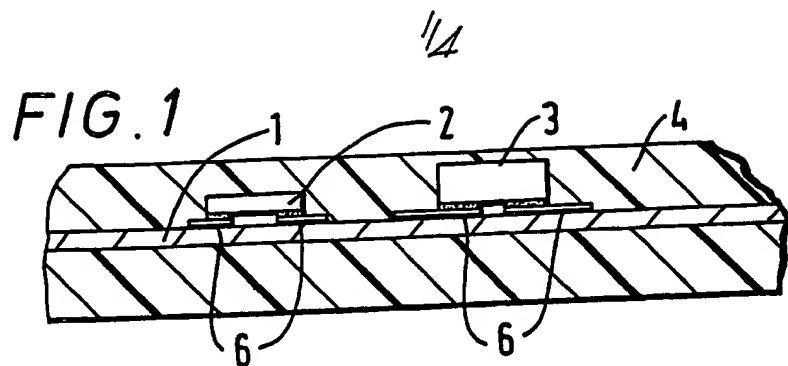


FIG. 5

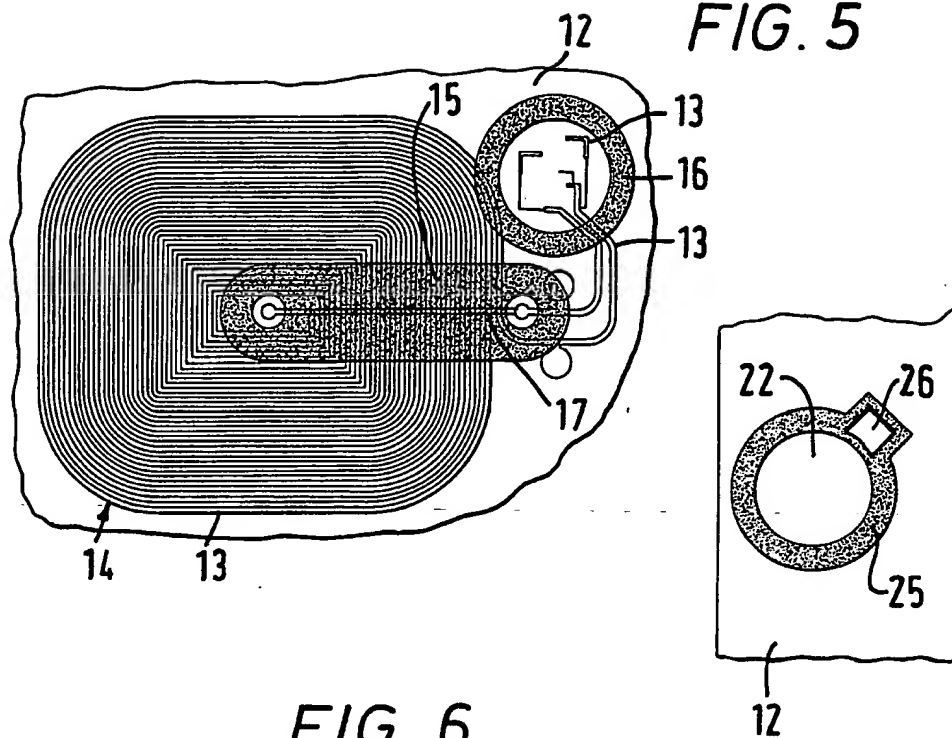
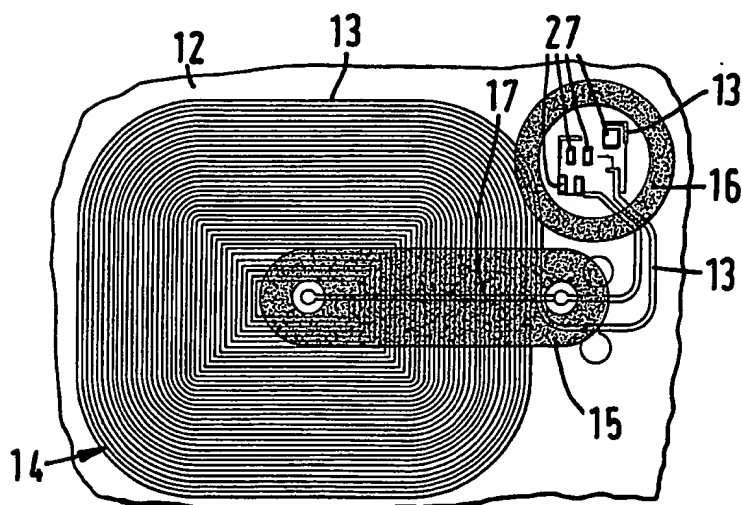


FIG. 6



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FIG. 7

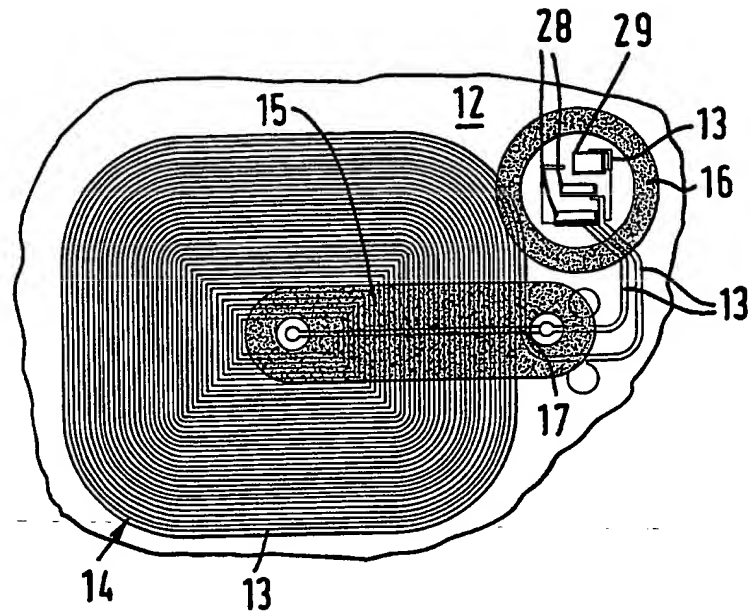
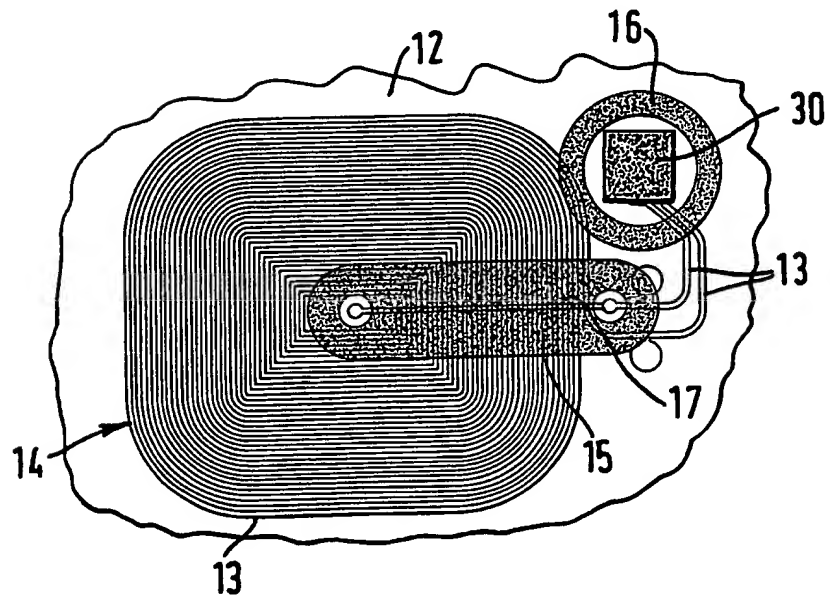


FIG. 8



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FIG. 9

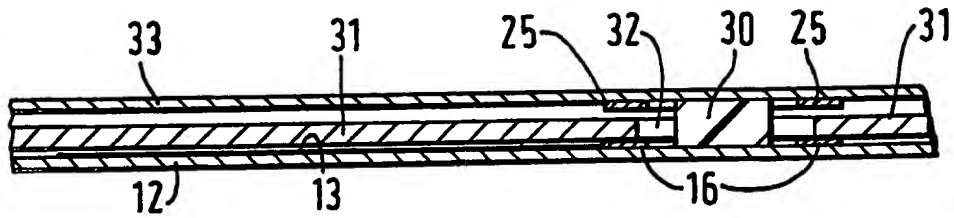


FIG. 10

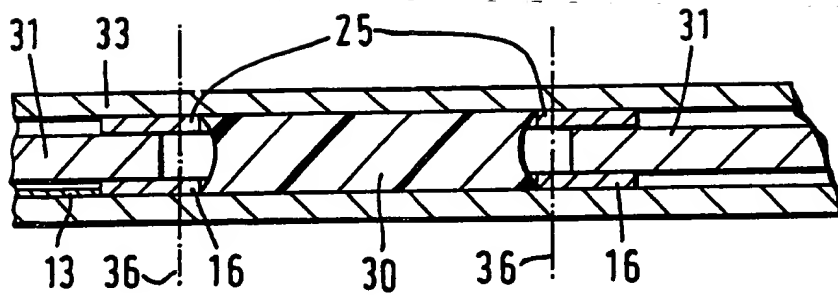
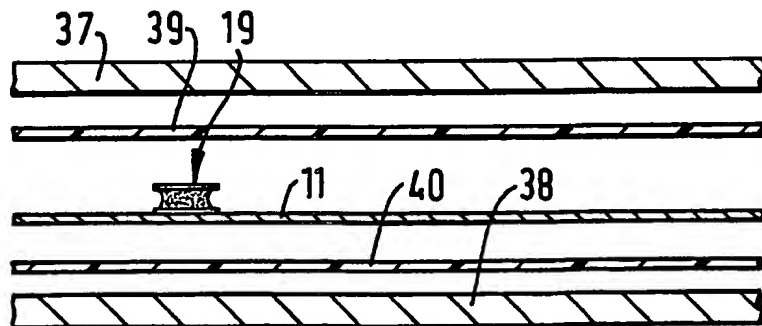


FIG. 11



A CARD

This invention relates to a card comprising a flexible printed circuit to which components are attached, and a process for manufacturing same, and more particularly but not exclusively to a card of the type commonly referred to as a "plastic card" wherein the printed circuit is embedded in the card.

It has previously been proposed to manufacture "intelligent" plastic cards, commonly referred to as "Smart Cards" in the manner illustrated in Figure 1 wherein components 2, 3 are mounted on copper tracks or pads 6 on the substrate 1, which copper tracks provide the electrical connection to the electrical components 2 and 3. The components 2 and 3 would typically be capacitors, integrated circuits, or similar devices. The printed circuit with the components mounted thereon would then be laminated between two sheets of plastics material 4 and 5. (Note that the term "printed circuit" as used in this specification should be considered to refer to any system of conductive tracks on an insulating substrate, whether such tracks are formed by printing, etching, vapour deposition or any other technique.)

The components 2 and 3 of Figure 1 are adhered to the conductive tracks 6 by using a silver loaded epoxy, or by conventional reflow solder techniques. However particular problems have been encountered due to the overall thickness restraints imposed on the circuit and components by the particular application with which the inventor was concerned, that being the production of circuits suitable for use in "plastic

cards".

In the production of circuits for plastic cards, the substrate 1 of the printed circuit has to be very thin, the entire assembly having to be within 760 microns in order to be embedded in a card of standard dimensions. In addition the substrate has to be flexible, for such thin cards will inevitably be bent in everyday use. This has necessitated that the components in turn be of minimal dimensions and requires that "naked" silicone integrated circuits be used which require to be encapsulated (not shown) prior to assembly in laminated layers 4, 5. In this environment the previously proposed conductive links forming by silver loaded epoxy adhesive or reflow soldering have been prone to failure, either on curing of the epoxy which tends to deform the substrate 1 or in use.

According to a first aspect the present invention provides a card comprising a flexible printed circuit carrying an electrical component secured to it by flexible adhesive.

This is particularly advantageous when the component is encapsulated on the printed circuit for it has been found that not only is the securing means less likely to fail on flexing of the card but that also the printed circuit board no longer tends to distort on curing of the encapsulant, it being presumed that this is because the properties of the encapsulant and adhesive are similar in nature. It has been found to be particularly advantageous to use the same compound for the flexible adhesive

and the encapsulant material for this provides a homogenous surrounding for the component reducing stresses on it. Furthermore this gives the advantage that the adhesive and encapsulant can be cured by the same process. The adhesive is preferably gelled prior to the components being encapsulated in order to ensure they are correctly retained in position, both while electrical connections are made, preferably by wire bonding, and during encapsulation.

In addition to the aforementioned advantages it has also been realised that because using a flexible adhesive it is necessary to make electrical connection by means other than the securing means, and this means it is no longer necessary for the component to be mounted on a region in which a copper track or pad is present and therefore preferably the adhesive is applied directly to the substrate of the printed circuit board such that the component can be mounted directly on it, reducing the overall thickness of the circuit/component assembly by the thickness of the copper track, typically 35 microns, which is significant when the entire assembly is 760 microns.

A further advantage of using adhesive to secure components is that the possibility of shorting under such components as a capacitor, possibly caused by misalignment of a capacitor on the copper tracks, is eliminated.

It has been found preferable to apply the adhesive and/or encapsulant by screen printing techniques as this ensures a relatively precise deposition of material

which enables the thickness of the material to be kept to the minimum required. This is particularly advantageous where a plurality of circuits are formed on a common substrate as they can all be simultaneously screen printed.

In accordance with a second aspect there is provided a method of fabricating a card, as set out in the claims of this specification. It will be realised that similar advantages to those set out above will be gained by using the claimed method.

One embodiment of the invention will now be described, by way of example only, with reference to Figures 2 to 11 of the accompanying drawings in which like numerals have been used to indicate like parts, and of which:

Figure 1 schematically illustrates a previously proposed arrangement (not in accordance with the invention) of electrical components in a plastic card;

Figure 2 is a perspective view of a plastic card in accordance with the present invention;

Figure 3 is a plan view of the card of Figure 2 having its top sheet 4 removed to reveal the printed circuit;

Figure 4 is a cross-section through the card along the line I - I of Figure 3; and

Figures 5 to 11 illustrate various stages in the production of the plastic card depicted in Figures 2 to 4.

Referring first to Figure 2 there is shown a perspective view of the final card which has the same external dimensions as a standard "plastic card". The card contains an integrated circuit. On Figure 2 it is possible to see edge portions of a substrate of the integrated circuit, exposed at a central part of each edge of the card. The integrated circuit communicates with interrogation units via an inductive link located at appropriate locations. The integrated circuit would normally contain a memory device and could be used for any number of purposes, for example recording banking transactions or recording zones of buildings etc to which entry has been gained by use of the card as an identity card.

Referring to Figure 3 there is illustrated a plan view through a section of the card 10 of Figure 2 in the plane of the card. From this and the cross-section along line I - I illustrated in Figure 4 it can be seen that a printed circuit 11 comprises epoxy/glass substrate 12 and conductive tracks 13, a substantial portion of which form conductive loop 14. Darkly shaded regions 15 and 16 comprise of a thermoset dielectric material. The purpose of the region 15 is to insulate a silver conductor 17 from the inductive coil 14. The purpose of dielectric layer 16 will be explained later.

An integrated circuit and capacitive components, not shown in Figures 3 or 4, are contained within a capsule-like element 19 which is separated by cut 18 from the

rest of the substrate 12. The region 20 of the substrate 12 is lowered below the plane of the printed circuit 11, the integrated circuit and capacitive components being located in potting compound 21 sandwiched between the portion of the substrate 20 and a capping portion 22 of the same material as the substrate 12.

The printed circuit 11 and element 19 are sandwiched between two outer sheets 23 and 24 of PVC thermoplastics material and two intervening layers (not shown in Figures 3 or 4), of polyester which is coated on both sides with a thermally activated catalyst adhesive by which the laminated structure is adhered. This polyester acts as a reinforcing layer preventing element 19 "breaking out" of the PVC layers 23 and 24.

The fabrication process of the card illustrated in Figures 2, 3 and 4 begins with a substrate sheet 12 of copper-clad epoxy/glass which is etched to form a large number of identical printed circuits 13, each as illustrated in Figure 5. On top of each printed circuit is printed a thermoset dielectric material indicated by the shaded regions 15, 16 which is cured in place. The function of circular part 15 is explained below. The linear part 16 serves as an insulator to separate printed conductive link 17 between inner and outer ends of a coil 14 defined by part of the printed circuit 13. Separated from a main part of the substrate by lines of weakness not shown are a number of strips (not shown), each carrying printed patterns 25 (only one of which is illustrated), with apertures 26 therein, which ultimately become the top reinforcing caps of the elements 19.

The substrate carrying the etched patterns is placed on a bed of a screen printing machine (not shown) and a screen placed over it. A squeegee is then used to print a low ionic epoxy encapsulant/adhesive material onto positions 27 as shown in Figure 6. This is a mixture of a resin and a catalyst which sets hard when cured. Suitable materials are, for example, available from Ablestick, Encaremix, or Dexter Hisol. The substrate is then placed in a "pick-and-place" machine which places components comprising of capacitors 28 and silicon chips 29, shown in Figure 7, onto the epoxy which acts as an adhesive to hold them in place. The silicon chips 29 at this stage are "naked", that is to say they are not encapsulated. A notable feature of this process is that the epoxy is applied to areas where there is no copper layer, this being unnecessary because of the adhesive attachment of the components. A saving of 35 microns in thickness is thus achieved as compared with arrangements where components are soldered on top of a copper track. It will be appreciated that this reduction of thickness may be of crucial importance in situations where there may typically be a requirement for the entire assembly not to exceed 760 microns. An advantage of using epoxy adhesive is that if suitably selected it remains in its adhesive state for a sufficient time period which exceeds the maximum period during which the screen printing machine is not being operated. This avoids the need to clean down the equipment.

The sheet substrate carrying the etched patterns and respective components positioned on it, is then baked until the epoxy has gelled, i.e. set but not hardened. This takes place under a flow of nitrogen to prevent oxidation of the copper. The

sheet is then placed on the work-holder of a wire bonding machine where it is held in position by a vacuum. Suitable machines for this purpose are commercially available. Wire connections are then made between contacts on the individual components to appropriate parts of the printed copper circuitry. This is done by an ultrasonically assisted diffusion welding process. The sheet is then placed back in the screen printer with a different stencil in place. This stencil is much thicker, its thickness being selected so that the same epoxy encapsulant/adhesive now to be deposited over the components is sufficient to cover them completely. Notably, this material is the same as that which was used for the adhesive. It does not have to be the same but it preferably has similar physical characteristics. After the removal of the stencil, the sheet is as shown in Figure 8, the components being encapsulated by the encapsulant 30.

Figure 9 shows in cross-section the next stage of the process where a copper spacer 31 having a plurality of apertures 32 (corresponding to each of the regions on the sheet having encapsulant 30 deposited thereon) is located on the sheet, 12. Previously placed on the copper sheet is each of the now separated strips 33, previously referred to, to form regions defined by printed patterns 25, from which regions reinforcing caps 22 will be formed. The spacer 31, with strips 33 located on it by means of pins (not shown for clarity), has been placed on top of the substrate. The whole arrangement is then pressed such that the patterns 25 are pressed into contact with the spacer 31 which is thus pressed closely down onto the circular part 16 of the dielectric material. It also presses the portions of the strip 33 defined by the

patterns 25 onto the, still soft, epoxy encapsulant/adhesive thereby pulling the entire assembly down to the desired height. During this process the encapsulant spreads out as shown in detail in Figure 10, but not as far as the edges of the spacer sheet. It is prevented from doing so by its meniscus acting against the inner edges of the copper pattern 25 and dielectric ring 16, which meniscus thereby defines the radius of the encapsulant.

The whole assembly is now placed in an oven and cured at a temperature of 150°C. This fully gels the encapsulant/adhesive both under the components and the encapsulant portion. The assembly is now placed on a rule die which forms cuts 34 which can be seen in Figure 3. These cuts are "horseshoe-shaped" and configured so that their free ends correspond with the slots 26 (see Figure 5) in the strip 33. Note at this stage that the ends of each cut are located on the copper pads 35 of Figure 3. The cutter presses through the structure as illustrated by dotted lines 36 in Figure 10, leaving the element 19 on a limb of the substrate 11, as is best seen from Figure 3, and leaving the spacer 31 and remaining portions of the strips 33 free to be removed.

It will be noted from Figure 3 that the electrical connections to the element run parallel to an edge of the card, in which direction the card is most resistant to bending, as opposed to across the hinge line which runs across the corner of the card where it is most susceptible to bending.

Using another rule die, cruciform shapes are cut out of the assembly to give each printed circuit the shape illustrated in Figure 3. This removes the epoxy/glass substrate from those areas which are to become the corners of the finished cards. It is notably these corner parts which are most subject to the type of manipulation which encourages de-lamination.

The printed circuit 1 with reinforced element 19 is now placed, as shown in Figure 11, between two outer sheets 37 and 38 of thermo plastics material in the pvc family with the inter-position of polyester layers coated on both sides with a thermally activated catalyst adhesive 21. The assembled sandwich is placed in a press where it is heated to cause lamination. During this stage the capsules 18 imbed themselves in each of the sheets of thermo-plastic material in such a way as to tend to centralise themselves between opposite faces leaving the plane of the substrate sheet 1 on the central axis as shown in Figure 4. The press now opens and the assembly is removed to a cutting machine where the individual cards as illustrated in Figures 2 and 3 are cut out.

**CLAIMS**

1. A card comprising a flexible printed circuit carrying an electrical component secured to it by flexible adhesive.
2. A card as claimed in claim 1 wherein the component is encapsulated on the printed circuit.
3. A card as claimed in claim 2 wherein the flexible adhesive is the same compound as the encapsulant material.
4. A card as claimed in claim 2 or 3 wherein the flexible adhesive and encapsulant are cured at the same time.
5. A card as claimed in any preceding claim, wherein the printed circuit comprises a substrate having conductive tracks thereon and wherein the component is bonded directly to the substrate in a region where no conductive tracks are present.
6. A card as claimed in any preceding claim wherein the flexible adhesive is applied by screen printing.
7. A card as claimed in any preceding claim wherein electrical connections between the printed circuit and the component are made by wire bonding.

8. A card as claimed in any preceding claim wherein the printed circuit and component are embedded in protective material.
9. A card substantially as hereinbefore described with reference to any one of Figures 2, 3, 4, 6, 7, 8 or 9 of the accompanying drawings.
10. A method of fabricating a flexible card comprising securing the electrical components to a printed circuit by means of a flexible adhesive.
11. A method as claimed in claim 10 wherein the component is encapsulated on the printed circuit.
12. A method as claimed in claim 11 wherein the adhesive is gelled prior to the component being encapsulated.
13. A method as claimed in claim 11 or 12 wherein the adhesive and encapsulant are cured at the same time.
14. A method as claimed in any one of claims 11 to 13 wherein the adhesive and encapsulant are the same material.
15. A method as claimed in any one of claims 11 to 14 wherein the encapsulant is applied by screen printing.

16. A method as claimed in any one of claims 10 to 15 wherein the adhesive is applied directly to the substrate of the printed circuit board.

17. A method as claimed in any one of claims 10 to 16 comprising screen printing the adhesive onto the printed circuit.

18. A method substantially as hereinbefore described with reference to any one of Figures 2, 3, 4, 6, 7 or 8 of the accompanying drawings.

**Patents Act 1977**  
**Examiner's report to the Comptroller under**  
**Section 17 (The Search Report)**

Application number

GB 9313750.3

**Relevant Technical fields**

(i) UK CI (Edition L ) B6A (AK)

(ii) Int CI (Edition 5 ) G06K

**Search Examiner**

G J W RUSSELL

**Databases (see over)**

(i) UK Patent Office

(ii)

**Date of Search**

6 OCTOBER 1993

Documents considered relevant following a search in respect of claims 1-18

| Category<br>(see over) | Identity of document and relevant passages                       | Relevant to<br>claim(s) |
|------------------------|------------------------------------------------------------------|-------------------------|
| X                      | GB 2253591 A (GEC) - see page 7 lines 2-5<br>from below          | 1, 2, 10,<br>11         |
| X                      | GB 2225283 A (DE LA RUE) - see page 8<br>lines 25-31             | 1, 2, 10<br>11          |
| X                      | EP 0359328 (TELECOMMUNICATIONS) - see<br>conductive adhesive (4) | 1, 2, 10,<br>11         |
| X                      | US 4889980 (CASIO) - see column 3<br>lines 35-37                 | 1, 2, 10,<br>11         |
| X                      | US 4682017 (KYODO) - see column 4<br>lines 44-47                 | 1, 2, 10,<br>11         |
| X                      | US 4483067 (US PHILIPS) - see column 2<br>lines 62-65            |                         |

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